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The effect of renewable energy application on Taiwan buildings: What are the challenges and strategies for solar energy exploitation?

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ABSTRACT

Global warming or environmental issues in countries with effective energy applications and management of environmental resources have become key concerns. Energy is an important factor for countries to achieve sustainable development. Therefore, we need to actively seek renewable energy technology innovations, assess for optimization of resource inputs and strategize to proceed with effective energy strategic planning. Presently, international renewable energy technologies have been undergoing gradual and steady development. Taiwan is highly vulnerable in energy security, but geographic conditions for the development of solar energy applications have created a considerable advantage. However, the total installed solar energy capacity is far less than might be expected. Consequently, this study proceeds to explore the main resistance and key factors that affect renewable energy application concerning Taiwan buildings. Through the evaluation decision-making system model and expert decision-making groups giving evaluation values and feedback, the study found the main influences and key factors, and propose strategies for energy development in the future to improve the quality and quantity of renewable energy applications and competitiveness of national energy. This research, in addition to providing references to relevant environmental energy systems for deployment and technological research and development, also provides developing and underdeveloped countries access to applications of solar energy technology assessment and forecasts for the future.

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Abbreviations: 3E, Economic development and Energy Exploitation and Environmental Protection; ACRE, Australian Centre for Renewable Energy; ASI, Australian Solar Institute; BEMOEA, Bureau of Energy under the Ministry of Economic Affairs; BIPV, Building Integrated Photovoltaic systems; CSP, Concentrating Solar Power; EPIA, European Photovoltaic Industry Association; FDM, Fuzzy Delphi method; FIT, Feed-in tariff; GW, gigawatt; H_0, Null hypothesis; H_1, Alternative hypothesis; IEA, International Energy Agency; kW, kilowatt; MBIPV, Malaysian Building Integrated Photovoltaic Project; MOEA, Ministry of Economic Affairs; MW, megawatt; PV, Photovoltaic; R&D, Research and Development; RD&D, Research and Development and Demonstration; RE, Renewable Energy; REP, Renewable Energy Plan; RES, Renewable Energy Source; RET, Renewable Energy Target; RETs, Renewable Energy Technologies; RPS, Renewable Portfolio Standard; SFP, Solar Flagship Program; SHCP, Solar Homes and Communities Plan; SPSS, Statistical Package for Social Science; SWH, Solar Water Heaters system

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1. Introduction

Global environmental concerns and the escalating demand for energy have accelerated worldwide attention on green energy, especially solar energy [1]. In recent years the international effort to reduce carbon emissions, thus, protecting the environment, while not stopping economic growth, has been a serious challenge and an important issue [2]. Many countries have put into use various types of renewable energy technologies (RETs) to promote research, development and demonstrations (RD&D). Therefore, RETs have become an important field of industrial competition internationally [3]. In Taiwan the green energy industry is also included in the development of key industries. Currently, both developed and developing countries are actively seeking alternative renewable energy sources. The European Union currently has provided input of the most resources between countries [4]. There are many types of renewable energy (RE) resource applications. Solar energy is the most dominant source among the renewable energy resources and appears quite attractive for electricity generation because it does not increase carbon dioxide emissions, is not harmful to the environment and is nature friendly [5]. Being able to direct and facilitate the application to daily needs for energy in various types of buildings, it has attracted worldwide attention [6].

The International Energy Agency (IEA) envisaged solar power accounting for 11% of global electricity production by 2050 and solar electricity contributing about 20% of the world's energy supply by 2050 and over 60% by 2100 [7]. It is clear that solar energy will play an important role in the future of energy. Thus, it will become the first choice of governments and private enterprises of many countries [8]. Renewable energy inputs have proven effective in developed countries (such as the United States, Germany and Japan), as well as in recently emergent countries (such as Spain, Italy and the Czech Republic); these countries continue to input and promote solar energy applications [9]. However, the main objective of Taiwan's renewable energy policy is to promote more diversified applications in Taiwan. In accordance with the Bureau of Energy under the Ministry of Economic Affairs (BEMOEA) “Energy White Paper”, “Challenge 2008: National Development Plan” indicated that the key project of renewable energy development and application in the future was solar energy. Taiwan is a very densely populated island, so the application of solar energy is mainly combined with buildings. Thus, the application of renewable energy in buildings is mainly solar energy [10,11]. This becomes the supporting background of this study.

However, through literature surveys and analysis this study discovered that there are many RE research documents concerned mostly with the development of energy application system technology research and development (R&D) and simulation, evaluation and forecasts of systems of innovative technologies. Application technologies for solar energy occupy most of these studies [5]. However, a country's input and the import of the applications of new energy technologies, according to the present state and resource conditions for preliminary planning, assist with the assessment of applications technology, the forecast of effects of imported technology and the review and improvement of import difficulties and obstacles. These relevant research documents have not received much attention. This study uses Taiwan as an example to conduct in-depth research and explore the practical application and situation of solar energy at present. These become the major support motivations of this study.

Presently, in the statistics on the cumulative installed capacity of renewable energy in Taiwan there is a considerable gap between planning objectives and practical solar energy applications. In order to explore and seek the main resistance and key factors influencing solar energy applications and development, this study is composed of three parts: (1) *Establishment of assessment factor variables*: Through literature review and systems engineering analysis the research can retrieve factor variables that affect solar energy applications; (2) *Establishment of an evaluation decision-making system*: The evaluation values and feedback from the Fuzzy Delphi Expert Questionnaires and expert decision-making groups (industry, government, research and academic) are used to find key influencing levels and factors in Taiwan; (3) *Draw up energy development strategy proposals for the future*: According to the results of the study, energy development strategies were proposed for the future. The results of this study are expected to improve and enhance the quality and quantity of renewable energy applications and the competitiveness of national energy. Moreover, the study findings will help to provide references for relevant environmental and energy systems concerning deployment and technological aspects of R&D, as well as provide developing and underdeveloped countries' applications of solar energy technology assessment and forecasting for the future.

2. Current status and trends of solar energy applications globally

In recent years, solar power generation systems have gained unprecedented attention as a method to solve the energy problem. Thus, solar energy is obviously environmentally advantageous relative to any other energy source. Nowadays, about 46 countries actively promote RD&D to deploy solar energy systems. The worldwide solar photovoltaic (PV) generation capacity continues to increase and has become a rapidly growing industry [12]. According to the European Photovoltaic Industry Association (EPIA) the installed capacity of solar PV systems may reach 688 GW in 2020. With an annual investment value of about 620 billion Euros from now until 2020, there will be more than one billion

people using solar power. This will create 3.62 million job opportunities [13]. In 2010, the global solar PV installing capacity was about 16.5 GW and the power generation was about 20 TWh. Five countries, Germany, Italy, Czech Republic, Japan and the USA, having the most total installed capacity, accounted for 79.4% of the capacity. Germany had 44.9% more than the four other countries in total [14] (shown in Fig. 1). Every country's growth rate for installed capacity of solar PV is quite high, especially Spain (shown in Fig. 2). This demonstrates countries which attach considerable importance to the development of solar energy applications and technology resource input.

Countries developing renewable energy applications vary according to lines of distribution of natural resources, conditions of economic development, characteristics of energy structure and development strategy of technical focus that adopts inputs and imports applications for renewable energy strategy [15,16]. Therefore, the IEA divided all renewable energy policies into nine groups: Education and Outreach, Financial, Policy Processes, Incentives/Subsidies, Public Investment, RD&D, Regulatory Instruments, Tradable Permits and Voluntary Agreements. Apparently all renewable energy policies require legal and fiscal support from governments [17]. This chapter introduces the electricity generation applications status, trends and implemented policies of solar energy of some successful countries and recently emergent countries such as Spain, Germany, the United States, Australia, Japan, China, Turkey, India and Malaysia.

2.1. Solar energy applications in successful countries

The most important solar resources in Europe are found in Spain. The Spanish government approved the “Renewable Energy Plan” (REP) in 2005; its overall aim was to meet the target of supplying 12% of primary energy demands and 30% of its demand for electricity from renewable energies by 2010 [4]. Spain's implementation of the solar energy strategy has included continued lowering costs and prices in system components for solar energy equipment, institutional economic support, versatility and modularity, minimum maintenance cost, and deployment concentrating solar power (CSP) plant [18]. The government, in addition to creating a high-quality environment for industrial development,

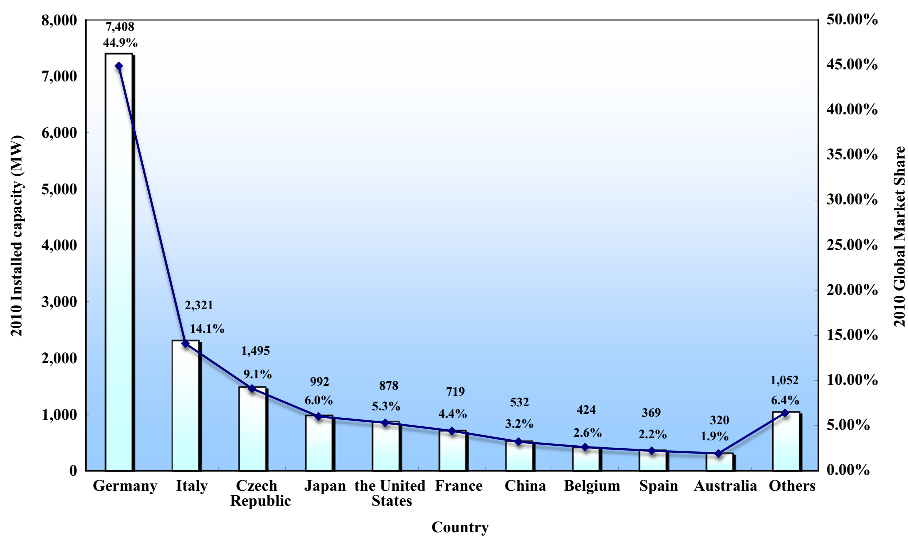

Fig. 1. Globally top ten countries installed capacity and global market share of solar PV in 2010 [14].

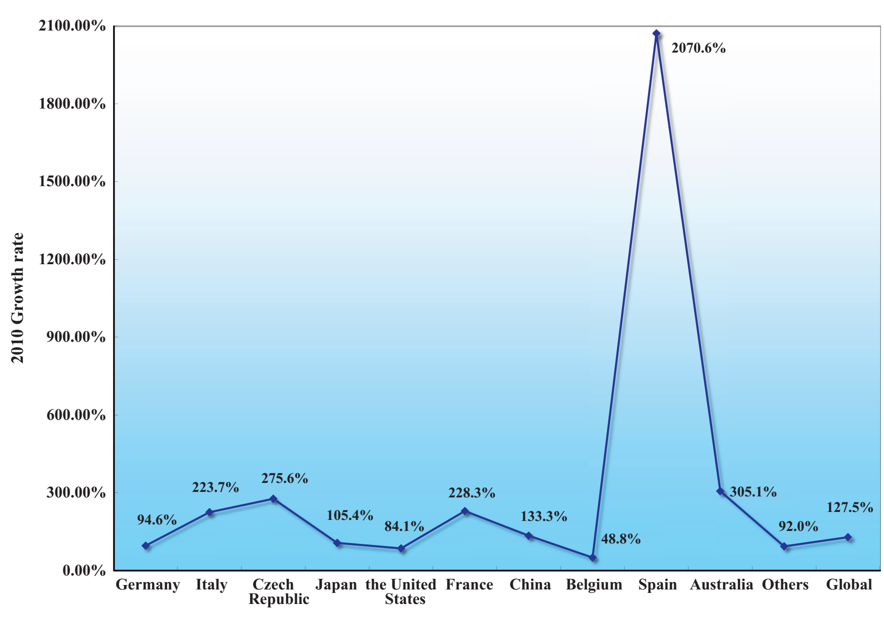

Fig. 2. Globally top ten countries growth rate for installed capacity of solar PV in 2010 [14].

also created more than 1300 employment opportunities [19]. Consequently, Spain is in a position to play a key role in the implementation of renewable energy technology in Europe [20].

Installed power in 2010 was approximately 7408 MW in Germany, which remains one of the highest installed solar PV systems capacities and more than a third of the global cumulative PV power installed. Germany has a diverse mix of solar PV systems applications: 40% of the PV systems were installed on residential buildings, 50% were installed as commercial roof top systems and 10% were installed as very large ground mounted systems [21]. Considering current installation rates, PV will be a major electricity source within a few years. Germany promulgated and implemented relevant laws, such as the "renewable energy law" and "renewable energy net pricing law". Through the support of government policies, the country's financial support, a high degree of green energy consciousness, and the support and participation of the people, the country can further promote a high employment rate [22].

The third largest PV market in 2009 was the U.S. with 1.45 GW of cumulative installed PV capacity [7]. Between 2000 and 2008, the annually installed grid-connected PV capacity in the U.S. grew from 4 MW to 290 MW at an average rate of 71% per annum. This rapid growth made the U.S. the third-largest global demand center, behind Germany and Spain. The U.S. has sufficient land area to provide PV development, which presents an attractive economic incentive for PV developers, system installers, financiers and PV service providers [23]. Therefore, in order to achieve growth in the market involving PV capacity, the U.S. Government should give investors important incentives [4].

In Australia, a solar PV system with a total of 320 MW was installed in 2010, a 305% increase over 2009. The government instituted policies and incentive programs such as "Australian Solar Institute" (ASI), "Australian Centre for RE" (ACRE), "Solar Homes and Communities Plan" (SHCP), "Renewable Energy Target" (RET) and "Solar Flagship Program" (SFP) [24]. Nevertheless, in Australia, solar PV market distortions and external environmental difficulties need to be overcome. There is also a resistance to policy mechanisms, technical difficulties with the renewable energy grid integrating and they must choose the best location to develop large-scale solar energy systems [25].

The total installed capacity of Japan's solar PV system in 2010 was 992 MW. Japan's PV system is mainly for private housing, collective housing or apartment buildings, public facilities, industrial and commercial facilities and buildings. The PV market development has been driven by residential PV systems with a capacity of 3–5 kW and PV systems with a capacity of 10–1000 kW for public facilities. Japan has developed rapidly in the field of solar PV cells, applying rooftop PV technology and incentive mechanisms to expand solar PV systems [26]. They are also actively improving solar cell technology and reducing the manufacturing cost of system components, to promote enhancement of the installed capacity of solar PV and obtain the leading edge position for PV technology development in the world [27]. Japan's solar market strategies to popularize, import and plan are considerable, making them an important representative in the global market supply [7].

China's total output of solar cells in 2007 was 1088 MW, ranking it first in the world [28]. Consequently, the market and development potential of solar energy is startling and worthy of sustained attention in the future [29]. Since 2002, the market share of China's PV increased from 1% to 35% [30]. The total installations of PV power in 2010 reached 532 MW; China intends to increase its capacity over 1.8 GW by 2020. The government has implemented a national technology related plan, critical equipment research and development, active deployment of a large PV plant, etc. [31]. The government also encourages the development of new energy and renewable energy in the building environment [32]. Currently, although Chinese enterprisers have begun to invest in the PV industry, they are faced with some difficulties that still need to be overcome, such as raw and processed materials, environmental pollution and the high cost of the most efficient technologies, which hinder their deployment.

2.2. Solar energy applications in recently emergent countries

Energy is one of Turkey's most important development priorities. Solar energy and PV-panel applications, in the world and especially in Turkey, experienced a rapid growth in production and investment. Education in the area of solar energy should be organized by public institutions to increase public awareness and applications. The individual participants should be encouraged, and the generation of PV cell production should include incentives. In Turkey, due to technological and economic impact, the resulting renewable energy does not have wide applications, but renewable energy usage should be increased year by year by government. Constant encouragement of policies and the ability to create more technological advantage incentives for learning cooperation internationally are areas in urgent need of attention [33].

In India a total renewable power generation capacity of 20,556.05 MW was achieved by 2011, which is about 11% of the total installed power generating capacity in the country. The government approved the "Jawaharlal Nehru National Solar Mission" (JNNSM) in 2009 which was aimed at development and deployment of solar energy technologies [34]. The energy strategies being achieved in India are solar PV research and development and demonstration projects, a tariff subsidy system and incentive mechanism and private sector projects to promote the maximum utilization of all forms of solar power to increase the share of renewable energy in the market, as well as promote the development and application of solar energy [35].

Malaysia reached the total renewable energy installed capacity of 20,493 MW in 2010. In the development of solar energy in Malaysia, in addition to the "Malaysian Building Integrated Photovoltaic Project" (MBIPV) as the main driving force to promote residential PV system applications, the government has formulated policies on renewable energy development, including laws, financial policy support, a tariff subsidy system, energy technologies R&D, renewable energy model projects, etc. [36]. These policies provide significant motivation and interest for the development and use of renewable energy technologies [37]. However, study and analysis of solar PV installed in residential houses revealed that the PV tariff subsidy system's return on investment is quite low, and the majority of people do not know about government incentives and policies [38]. Additionally, the renewable energy development policy has some limitations, such as lack of coordination and consistency in policy framework, lack of regional policy innovation, an unhealthy and incomplete financing and investment system and inadequate investment in technical research and development [39]. Moreover, in terms of technology, they are faced with critical challenges including cell efficiency, skilled technical personnel for maintenance, operation and maintenance costs, etc. [40].

Summarizing the above, for any green technology industry to succeed, the right support mechanisms must be in place to create the market. One of the key stumbling blocks is the prohibitive pricing of renewable energy that gives households and businesses little incentive to adopt the technology, especially in developing and underdeveloped countries. How to establish an optimal combination of energy settings becomes the countries' energy policy thinking spindle. Countries' involvement in the promotion of solar energy applications and import of strategic planning vary a lot; therefore, government implementation of policy instruments and measures are also different [3]. In this paper we study

countries who implemented important policy-making experiences; and background factors are used to carry out systematic analysis and summary, as important references for the development of an evaluation decision-making system model.

3. Current status and challenges in solar energy applications in Taiwan

3.1. Current status of solar energy applications

3.1.1. Solar energy policies and prospects

Taiwan depends on a ratio of imported energy up to 99.24%, and therefore, active promotion and application of renewable energy, technical R&D and improved efficiency of energy use are important issues in the national energy policy [41]. Currently, sustainable development of an energy policy is necessary in order for energy and resources to achieve sustainable utilization. Thus, gradual implementation incentives and rewards for renewable energy applications practices and various techniques need to be offered, especially in solar energy applications.

Since 2000, BEMOEA has promulgated and implemented laws, regulations and subsidy operations associated with solar energy applications, to promote solar PV generation system installation (shown in Table 1). In Taiwan, the policies of renewable energy development will require a breakthrough in the current status to connect with the international trend. The introduction and promotion of policies to enhance the installed capacity of a solar PV system has a positive effect.

3.1.2. Target for solar energy

In recent years, driven by policy promotion and investment, the government has actively pushed for increased renewable energy capacity. The 2007 installed capacity target was set at 1000 MW in 2025; the target increased to 2000 MW when the “Renewable Energy Development Act” was passed in 2009 [42]. In 2010 the government considered the principles of renewable energy technologies to be mature and cost-effective, so it enhanced the installed capacity target to 1250 MW in 2020 and 2500 MW in 2030 [12].

At the end of 2010 BEMOEA planning for promotion plans and objectives of renewable energy included a total cumulative installed capacity necessary to achieve 513.9MW; the renewable energy in a total installed capacity ratio must be 10.0%, the solar energy applications must be 2.1 MW and the total installed capacity ratio must be 0.04% (shown in Fig. 3).

3.1.3. Development status and deployment restrictions of solar energy

Taiwan has favorable conditions for the development of solar energy applications. Nevertheless, the total installed solar energy capacity is far less than might be expected. In 2012 the total cumulative installed capacity of renewable energy was only 342.0 MW. Moreover, its occupied total installed capacity ratio was only 6.65% [43]. The analysis showed that the renewable energy had an average effectiveness of only 9.19 MW per annum and an average growth index of only 0.09 per annum, with a total cumulative installed solar energy capacity of only 3.54 MW. Its occupied total installed renewable energy capacity ratio was only 0.06%, while the solar thermal system installation penetration rate was only 7.12% of residential houses (shown in Fig. 3) [41].

Besides, solar system installation also encountered many restrictions; these included gaps between the regulations and current status in the process of equipment identified, land use regulation issues, time-consuming wholesale purchase application procedures, etc. These are currently the practical issues in the development of solar energy applications. In view of this, the implementation of solar energy exploitation obviously faces great challenges and resistance resulting in poor performance. Hence, it is necessary to clarify the resistance and key factors affecting renewable energy application on Taiwan buildings.

3.2. The challenges of solar energy applications

This chapter, through literature review and analysis of related solar energy system applications, explores and compiles challenges arising in solar energy applications in Taiwan, and then, accordingly, collects indicator variable sets as the basis for development of evaluation decision-making system framework.

Renewable energy is not fully developed in Taiwan resulting in lack of competition in the market. Therefore subsidy programs need to be implemented. Taiwan is still at a demonstration stage, even though an electricity price subsidy system has been implemented. The RE economy is not yet cost-competitive compared with conventional fossil fuel energy. Thus, popularizing solar energy applications is still very difficult [44]. Taiwan should formulate relevant policies and financial incentive measures, demonstrate and advocate solar energy applications and establish a subsidies act to encourage enterprises to install solar PV systems [45]. Also, the government should encourage architects to install solar energy systems and building integrated photovoltaic systems (BIPV) in public buildings and help to develop a Solar City. Solar PV systems are now widely installed in schools to achieve the educational significance [46].

Table 1
Taiwan promulgated and implemented laws, regulations and subsidy operations associated with solar energy applications [12].

Year	Laws, regulations and subsidy operations associated with solar energy applications
2006	Subsidy operations guidelines for solar photovoltaic system
2009	Renewable energy development act Green energy industry sunrise program
2010	Renewable energy electricity wholesale purchase rates and its formulas Public buildings solar photovoltaic demonstration and application, and guidelines of setting of application and operations Operations guidelines for renewable energy electricity acquisition Subsidy and incentive measures for thermal utilization of renewable energy Subsidies to apply and measures to examine for electricity costs of renewable energy Renewable energy generation equipment demonstration incentives
2013	Ministry of economic affairs subsidies to promote Solar Community Subsidies guidelines for assist the solar photovoltaic industry to expand overseas markets

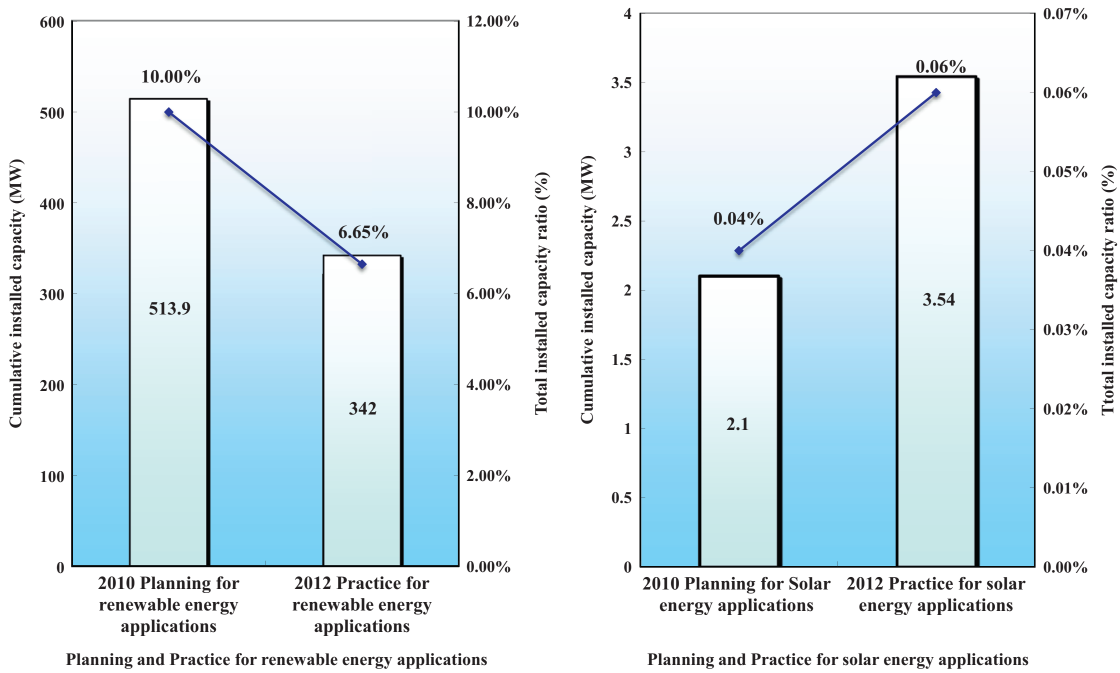

Fig. 3. BEMOEA planning objectives and practical for renewable energy and solar energy applications [41,43].

However, the development of solar technology still must overcome the obstacles of technical, financial and legislative management systems. Consequently, countries who adopt more RE policies will enhance the capacity of the systems installed. An incentive/subsidy policy is common to expand the popularity of solar energy applications [47,48]. Besides, government should tax fossil fuel products and adopt appropriate and flexible policy positions to achieve the goals of different stages in RE market development [49]. Moreover, the government should encourage energy technology transfer, provide subsidy incentive for solar water heaters systems (SWH) and establish a national key laboratory focusing on renewable energy R&D [50].

Currently, many factors affect the application and popularity of solar energy systems in Taiwan, such as lower energy density, high cost of power generation, power supply instability, inadequate financial incentive programs, long payback periods, availability of local installers and climatic conditions [51,52]. The main barriers to market acceptance of the installation of solar energy systems are the market price and investment incentives. Thus, local conditions and potential, such as solar radiation, should be assessed and countries must address key factors of cost and the energy price index [53]. Factors affecting the potential market of solar water heaters systems in Taiwan are climatic conditions, structure of population, types of urban buildings, types of residential buildings, energy prices and incentive systems and family composition [54]. Currently financial incentives are the key factors in countries which promote SWH. A long-term national plan is the driving force behind the expansion of local markets, but it is worth considering that a rapidly expanding market size and a high level of subsidies outstrip the total cost of installation. This will result in negative effects on market development [55].

In summary, through numerous literature reviews and analysis we identified the barriers, predicaments and challenges to current applications of solar energy systems. However, those literatures did not indicate that implementation of solar energy systems encountered the main challenges and resistance by the scientific research method to provide lessons and reference for countries' applications of solar energy systems in the future. This study was carried out to summarize influencing factor sets and influencing factor clusters and to further establish the evaluation decision-making system model.

4. Methodology

4.1. Research framework and methods

The primary goal of governments' renewable energy policies is to accelerate the process of obtaining more renewable energy installed capacity. However, in actuality there are multiple goals that the renewable energy policy intends to achieve. Komor and Bazilian considered that development of renewable energy applications is driven by many policies and incentive factors such as energy goals, environmental goals and economic goals. Ireland is a good example [56]. IEA member country policymakers believe that the development of renewable energy applications will help improve energy security, environmental protection and economic development [57]. Taiwan is active in the development and application of renewable energy. In 2008, declarations of the principles of sustainable energy policies stated that development of renewable energy policies should achieve the goals of economic development, energy exploitation and environmental protection (3E) [58].

This paper uses the research framework and methodologies of application to explore and clarify the main challenges and key resistance facing current solar energy applications and development. The process diagram of research framework and methodologies is shown in Fig. 4. The research process adopted methodologies and phased achievements as follows.

- *First stage*: *Literature survey and analysis*
  Document data collection, systematic and objective analysis of solar energy applications status and trends in global and solar energy applications, status and challenges in Taiwan; proceeded to classification of main resistance and key influencing indicators of variable sets.
- *Second stage*: *Systems engineering analysis*
  According to the 3E (economic development, energy exploitation and environmental protection) principles of Taiwan's sustainable

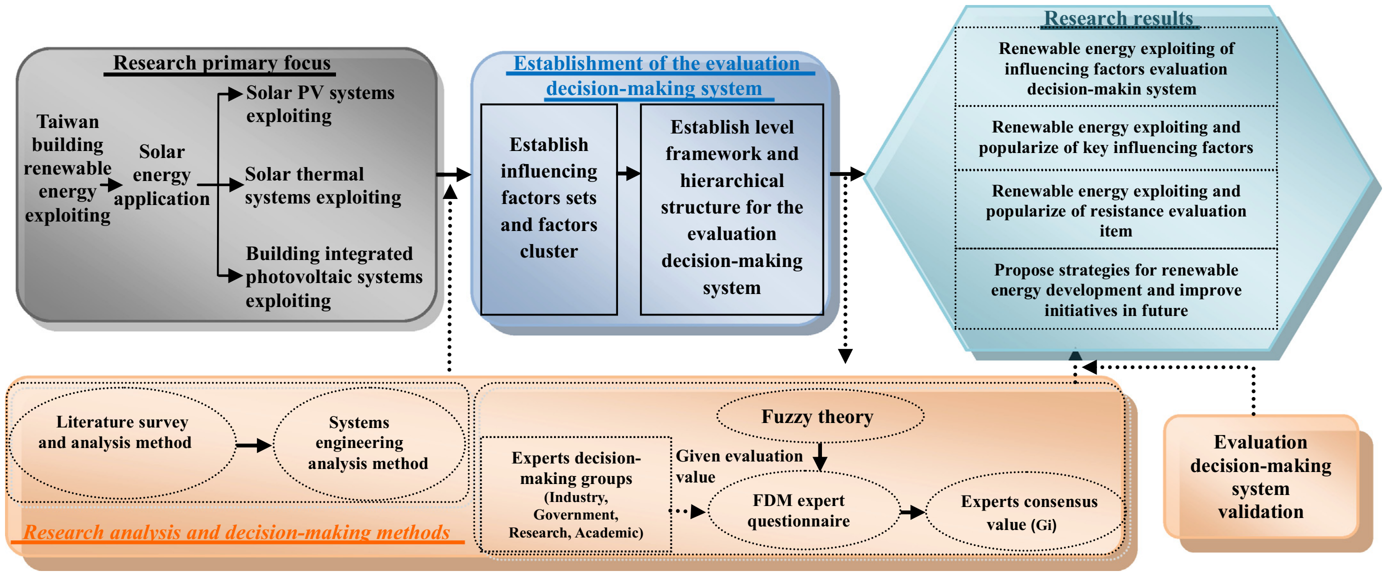

Fig. 4. The process diagram of research framework and methods. (Gray single-lane expressed removed factors after screening and decision-making).

energy policies, proceeded with systematic classification and analysis to establish influencing factor sets and factor clusters through systems engineering analysis to establish an evaluation decision-making system of the framework and hierarchy.

- *Third stage*: *Fuzzy Delphi Method*
  Application of Fuzzy Delphi Method (FDM) using expert questionnaires through the fuzzy evaluation value given by expert decision-making groups; proceeded with screening and decision-making of assessment factors to find key influencing levels and factors.
- *Fourth stage*: *Evaluation decision-making system validation*
  This stage applies SPSS (Statistical Package for Social Science) statistical methods to detect and validate the correlations of the overall hierarchical framework and independence of each assessment factor, and further proposes strategies for energy development proposals in the future.

4.2. Establish assessment models of the framework and hierarchy

This study identifies resistance and influencing factors based on the study of influencing factors and application evaluations for solar energy development through domestic and foreign literature surveys and analysis and expert decision-making groups' screening and decision-making, to further explore the issue that Taiwan buildings are influencing factors of renewable energy application.

This research, to explore the identification of influencing factors for solar energy application, follows the goals of Taiwan's formulated national sustainable energy policy programs containing three aspects: economic development, energy exploitation and environmental protection. Through systems engineering analysis a list of important factors and levels that affect renewable energy application on Taiwan buildings was compiled. Then we established influencing factor sets and factor clusters and a systematic evaluation decision-making system model as framework of assessment items for the Fuzzy Delphi Expert Questionnaire (shown in Fig. 5).

4.3. Application of Fuzzy Delphi method

The Fuzzy Delphi Method combined with fuzzy theory to amend the traditional Delphi Method implies the lack of ambiguity by Murray et al. [59]. Following up on Ishikawa et al.'s application of the concept of cumulative frequency distribution and fuzzy integrals, the opinions of expert decision-making groups were integrated into fuzzy numbers, and then, the geometric mean was used for the basis of decision-making and screening assessment system by expert decision-making groups to avoid the impact of extreme values [60].

First, this study established the evaluation factors' framework, and then, based on expert groups, gave evaluation values of the assessed factors to apply FDM to fuzzy evaluation value computing. The application steps, operational process and framework were as follows (shown in Fig. 6):

Step 1: *Set up the hierarchical structure and level framework for the evaluation decision-making system*
Through literature surveys and system engineering analyses our research goals assessed items of integration and classification, further setting up the hierarchical structure and level framework for an evaluation decision-making system. The hierarchical structure contains four levels (Levels 1–4). The first level indicates the main goal which is to assess the main resistances and key factors that affect renewable energy application on Taiwan buildings. The second and third levels consist of three aspects (ED, EE and EP) and nine objectives (O1–O9). Finally, the fourth level contains the key factors and consists of forty-five criteria (C01–C45). The hierarchical structure and the related definition abbreviation code for the overall evaluation decision-making system is shown in Fig. 5.

Step 2: *Gather opinions of the expert decision-making groups*
The main purpose of the Fuzzy Delphi Expert Questionnaire Survey was to verify the correctness and rationality of the contents of the evaluation decision-making system model, as well as carry out screening of the framework and factor items of the evaluation system. The main objective of the expert questionnaire was architecture and the relevant renewable energy field. Fuzzy Delphi Expert Questionnaires were given to seventeen experts in industry, government, research and academic decision-making groups. The questionnaires rated factors according to the importance to give a fuzzy evaluation value for each assessment factor.

Step 3: *Establish the triangular fuzzy function*
Ishikawa et al. proposed the Max–Min Method to establish the triangular fuzzy function values in this study [60]. Through the Fuzzy Delphi Expert Questionnaires the study obtained evaluation values for each assessment factor. These were used to

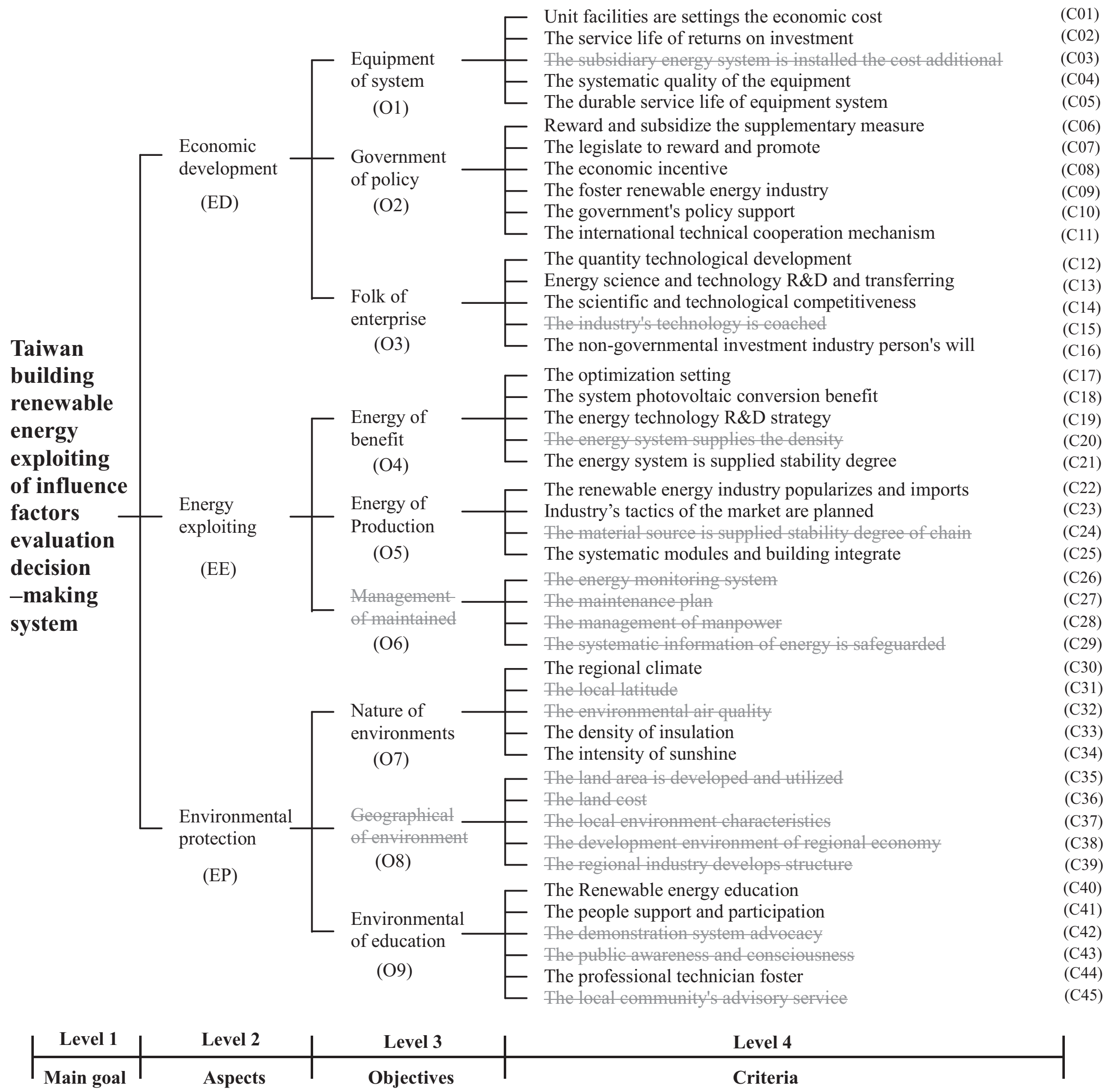

Fig. 5. Taiwan building renewable energy exploitation of influence factors evaluation decision-making system model. (Gray single-lane expressed removed factors after screening and decision-making)

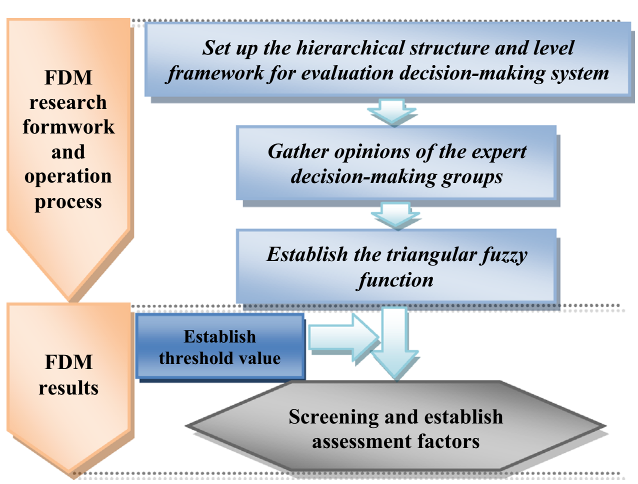

Fig. 6. Fuzzy Delphi Method operation process and formwork.

establish the "maximum acceptable value" cumulative number function F1(x) and the "minimum acceptable value" cumulative number function F2(x). Calculated separately, these can provide membership functions, and in this area the two membership functions that are interlaced with gray areas give the predicted value of m (shown in Fig. 7).

Step 4: Establish each influencing factor of the triangular fuzzy function

The FDM application used triangular fuzzy functions to cover the opinions of expert decision-making groups. Therefore, the upper limit of a generalized average function U_A (maximum), and the lower limit L_A (minimum), and membership degree 0 give the two endpoints of the triangular fuzzy number. Then, using the geometric mean number of M_A as the opinions of the majority of decision-makers, its membership is 1. That means that between the L_A and U_A there is a value representing each different possibility of consensus view, and each view is given a degree of possibility. Through the following calculation formulae (1)–(3) one can obtain the triangular fuzzy function of each influencing factor:

$$N_A = (L_A, M_A, U_A)$$

$$L_A = \mathrm{Min}(X_{Ai}), i = 1, 2, 3, \ldots, \mathrm{n} \quad (1)$$

$$M_A = (X_{A1} \times X_{A2} \times \ldots X_{An})^{1/n} \quad (2)$$

$$U_A = \mathrm{Max}(X_{Ai}), i = 1, 2, 3, \ldots, n \quad (3)$$

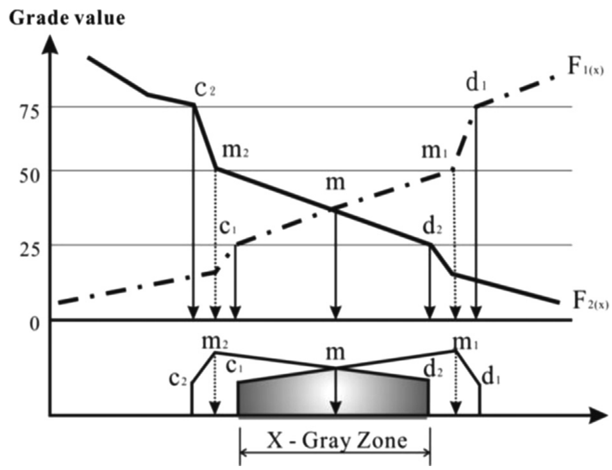

Fig. 7. The Max–Min predicted value [60].

A is the influencing factor; i denotes the expert; N_A is each influencing factor of the triangular fuzzy function; X_{Ai} is the evaluation value of the i-th experts decision-makers for the A-th items of influencing factors; L_A is the lower limit of evaluation value of the experts decision-makers for the A-th items of influencing factors; M_A is the geometric mean number of evaluation value of the experts decision-makers for the A-th items of influencing factors; and U_A is the upper limit of evaluation value of the experts decision-makers for the A-th items of influencing factors.

Step 5: *Screen assessment items of the influencing factors*

Based on the above values obtained from triangular fuzzy functions, one can screen the assessment items of the influencing factors. Therefore, this study applied the geometric mean to represent the majority opinion of the expert decision-making groups. This study applied each triangular fuzzy function of the geometric mean (X_A) as the membership degree, representative of expert decision-making group consensus values for the assessment of goals and factor evaluation values. Finally, the threshold value (S) is used to screen the importance degree of influencing factor items (A). Assessment items of influencing factors screening methods and principles of the calculation formulae (4) and (5) are as follows:

$$X_A \geqq S, \text{ Accept assessing items of the A influencing factor;} \quad (4)$$

$$X_A < S, \text{ Delete assessing items of the A influencing factor.} \quad (5)$$

5. Research content design and analysis

5.1. Screen and establish evaluation decision-making system

Fuzzy evaluation values were given by expert decision-making groups. This study found that after the comprehensive fuzzy operation, each assessment item in expert decision-making consensus values was quite high in the overall evaluation decision-making system, and each assessment item had an importance approval degree of more than 54%. Therefore, this study must not only consider the expert decision-making consensus value of convergence, and be in accordance with the study's set-up of goals and purposes to be achieved, but also consider improving the overall study of rigor, reliability and validity. In order to achieve the threshold value of objectivity this study adopted the expert decision-making groups' decision-making assessment item of evaluation value through the calculation of the geometric mean and the discussion at the expert decision-making group conference. Consequently the threshold value of Gi was established as 7.0000 [61–63].

Assessment items of the overall evaluation decision-making system through the use of the Fuzzy Delphi Expert Questionnaires achieved the evaluation value given by the expert decision-making groups. Then, the original forty-five assessment factors from the overall evaluation decision-making system, after the threshold value screening and decision-making, were reduced to twenty-seven assessment factors. The original evaluation system, after screening and decision-making, accounted for 60% of the original evaluation decision-making system, shown in Fig. 5.

5.2. Expert questionnaire survey and statistical analysis

This study obtained evaluation values and other relevant data on each assessment factor that applied FDM to comprehensive fuzzy computing. From Table 2 it can be seen that the assessment item of each influencing factor Zi (test value) had a value greater than 0. This shows that the opinions of the expert decision-making groups reached consensus, and each assessment factor had convergence.

Assessment factor screening results showed that the evaluation decision-making system produced a total of eighteen evaluation factors with a Gi value lower than the threshold value of 7.0000, so these were deleted (shown in Table 2). The FDM expert's questionnaire results for *Gi* values showed that each assessment factor in the evaluation decision-making system which obtained the expert decision-making groups received a score higher than 7.1325 on the recognition degree of importance. The geometric means of the “Maximum value”, “Optimum value” and “Minimum value” show that the maximum values go up to 9.0455, the optimum value is 7.8626, and the minimum value is 3.6324. These represent degrees of membership in the triangle fuzzy functions formed by the expert decision-making groups from which further research and analysis obtained the evaluation value of the expert decision-making groups for assessment goals and influencing factors where the majority showed a high degree of consensus.

This study, through the process of research design, found the main resistance and key influencing factors which affect exploitation and promotion of solar energy in Taiwan. The main resistance, i.e. the third level of objectives from the evaluation decision-making system model totaled seven items. In the second level of aspects, these objectives are as follows:

- Aspects of “Economic development” (ED) are “Equipment of system” (O1), “Government of policy” (O2), “Folk of enterprises” (O3).
- Aspects of “Energy exploitation” (EE) are “Energy of benefit” (O4), “Energy of production” (O5).
- Aspects of “Environmental protection” (EP) are “Natural of environment” (O7), “Environmental of education” (O9).

The key influencing factor, i.e. the fourth level of criteria from the evaluation decision-making system model totaled twenty-seven items. In the third level of objectives, the criteria and Gi value are as follows:

- Objectives of “Equipment of system” (O4) are C01 (8.9834), C02 (7.9498), C04 (9.2372), C05 (7.8445).
- Objectives of “Government of policy” (O2) are C06 (7.8778), C07 (8.9273), C08 (9.1328), C09 (7.9809), C10 (9.0344), C11 (7.2350).
- Objectives of “Folk of enterprises” (O3) are C12 (7.8887), C13 (7.5911), C14 (7.1325), C16 (8.5425).
- Objectives of “Energy of benefit” (O4) are C17 (8.6221), C18 (7.4020), C19 (8.0851), C21 (7.3573).

Table 2
The results of assessment factors screening and decision-making by Fuzzy Delphi Method [59,60].

Aspect of second level	Objective of third level	Criteria of forth level	Geometric mean			Expert decision-making consensus values	Test value	Screening results
			Oi	Ai	Ci	Gi	Zi	
ED	O1	C01	8.7502	7.2244	5.1908	8.9834	3.5594	–
		C02	8.6291	7.0312	4.8526	7.9498	3.7764	–
		C03	7.1230	5.6164	3.7484	5.5967	1.3746	Deleted
		C04	8.8410	7.3707	5.2369	9.2372	4.6040	–
		C05	8.6529	7.0671	5.1189	7.8445	1.5340	–
	O2	C06	8.6333	7.2964	5.2462	7.8778	1.3871	–
		C07	8.9792	7.8626	5.9020	8.9273	1.0772	–
		C08	9.0750	7.7697	5.8220	9.1328	2.2530	–
		C09	8.6681	7.1481	5.2928	7.9809	1.3753	–
		C10	9.0455	7.6328	5.7165	9.0344	1.3290	–
		C11	8.2690	6.4054	4.3593	7.2350	3.9097	–
	O3	C12	8.6333	7.2173	5.2649	7.8887	0.3684	–
		C13	8.5682	6.9707	5.0214	7.5911	0.5468	–
		C14	8.1943	6.6048	4.7938	7.1325	0.4005	–
		C15	7.9911	6.5298	4.9454	6.7526	0.0457	Deleted
		C16	8.9000	7.3077	5.3305	8.5425	1.5695	–
EE	O4	C17	8.9133	7.4345	5.4453	8.6221	1.4681	–
		C18	8.4429	6.6000	4.8967	7.4020	0.4537	–
		C19	8.8931	7.3953	5.6290	8.0851	1.7359	–
		C20	7.9428	6.4806	4.6904	6.5093	0.7476	Deleted
		C21	8.4281	6.8867	5.1059	7.3573	0.3222	–
	O5	C22	8.4555	6.6132	4.3011	7.5438	4.1544	–
		C23	8.7899	6.7900	4.6372	7.8572	2.1527	–
		C24	8.0723	6.5896	4.7345	6.7232	0.6621	Deleted
		C25	8.3219	6.7297	4.5546	7.1752	0.7673	–
	O6	C26	8.3489	6.5433	4.4528	6.9514	1.8961	Deleted
		C27	8.2236	6.6600	4.7479	6.6619	0.4757	Deleted
		C28	7.2244	5.6863	3.9491	6.3205	2.2753	Deleted
		C29	7.7774	6.0215	4.0227	6.3346	2.7546	Deleted
EP	O7	C30	8.8681	7.1644	5.0748	8.4959	2.7932	–
		C31	7.9506	6.3011	4.0493	6.3728	0.9013	Deleted
		C32	7.4910	5.9399	3.7806	5.8239	0.7104	Deleted
		C33	8.9651	7.4970	5.3957	9.0337	3.5695	–
		C34	9.0155	7.6330	5.6119	9.2893	2.4036	–
	O8	C35	7.5887	5.6979	3.6324	5.8140	1.9563	Deleted
		C36	8.0954	6.3375	4.2978	6.7234	0.7977	Deleted
		C37	8.4547	6.6469	4.5217	6.9871	1.7330	Deleted
		C38	7.7912	5.9533	3.8728	6.2436	1.9184	Deleted
		C39	7.5065	5.6779	3.6435	5.7300	1.8630	Deleted
	O9	C40	9.0066	7.1734	5.0684	8.5391	2.9382	–
		C41	8.6224	6.8143	4.6068	7.3943	3.0156	–
		C42	7.9006	6.4380	4.5132	6.3158	0.6126	Deleted
		C43	8.2066	6.6908	4.7214	6.6046	0.4852	Deleted
		C44	8.5247	6.9079	4.9581	7.4505	1.5666	–
		C45	7.5715	6.0215	3.9963	5.4157	0.5752	Deleted

- Objectives of "Energy of production" (O5) are C22 (7.5438), C23 (7.8572), C25 (7.1752).
- Objectives of "Natural of environment" (O7) are C30 (8.4959), C33 (9.0337), C34 (9.2893).
- Objectives of "Environmental of education" (O9) are C40 (8.5391), C41 (7.3943), C44 (7.4505).

This paper further processed the consensus value of each objective in the evaluation decision-making system to a unified average, as shown in Fig. 8. The most important objective was "Government policies"(O2), the expert consensus value on average was up to 8.3647; the second most important objective was "Equipment systems"(O1), the expert consensus value on average was up to 7.9223. These two objectives affect the main resistance and challenges to solar energy applications in Taiwan. Relatively, the objectives of "Geographical of environment" (O8) and "Management of maintenance" (O6) have low consensus values, only 6.2996 and 6.5671, respectively (shown in Fig. 8). Therefore, government should be the critical innovator, to strengthen the industry, to establish effective strategic improvement initiatives, to promote popularization of development and application of renewable energy and to improve the quality and quantity of the overall renewable energy applications in Taiwan.

5.3. Evaluation decision-making system validation

5.3.1. Correlation test analysis

The assessment factors were determined after screening and decision-making were carried out to detect the correlations of each assessment factor in this stage. Content was tested assessment factors between the "second level" (three aspects) and "third level" (seven objectives), and the "third level" (seven objectives) and "fourth level" (twenty-seven criteria) to promote more reliability

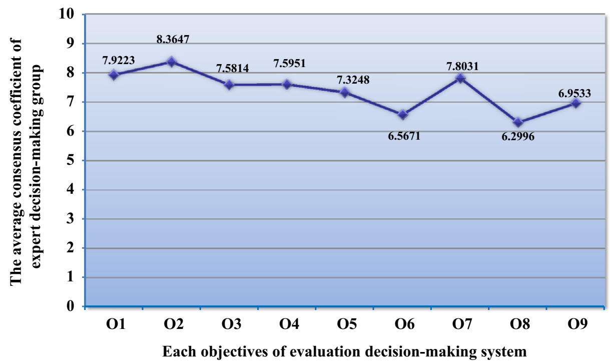

Fig. 8. The consensus value of each objective in the evaluation decision-making system to a unified average.

and validity of the overall hierarchical framework and each assessment factor.

In this study, the maternal sample was a professional field of decision-making groups with the implementation test of a maternal sample number≤30 and consequently the “Spearman rank correlation test” method of the nonparametric statistical method was adopted [64]. The implementation was as follows:

Statistical hypotheses: correlation test between the level variables.

- Null hypothesis (H_0): there is no significant correlation between the levels' variables;
- Alternative hypothesis (H_1): there is significant correlation between the levels' variables.

Spearman rank correlation coefficient formula (6) is as follows [65]:

$$r = 1 - \frac{6\sum d^2}{n(n^2-1)} \tag{6}$$

In the above formula, $d = Xr - Yr$; Xr are the ranks of the sample observations X; Yr are the ranks of the sample observations Y; and n is the logarithm of X and Y.

The test analysis results, through SPSS for windows statistical software, are as follows:

- The correlation of each variable between the second and third levels and the third and fourth levels reaches a significant level ($0.01 < P < 0.05$).
- This study not only can refuse the null hypothesis but also can establish relevance and rationality for each level (shown in Table 3).

5.3.2. Independence test analysis

This stage detects the independence of each assessment factor. The detected contents are second level, third level and fourth level of various aspects and objectives, and various criteria assessment factors of independence tested to promote more reliability and validity of the overall hierarchical framework and each of the assessment factors. This study adopted the “Fisher's exact probability test” method of the nonparametric statistical test [66]. The implementation was as follows:

Statistical hypotheses: Independence test between the level variables.

- Null hypothesis (H_0): there is significant independence between the levels' variables;
- Alternative hypothesis (H_1): there is no significant independence between the levels' variables.

Fisher's Exact Probability Test formula (7) is as follows [67]:

$$p = \frac{(A+B)!(C+D)!(A+C)!(B+D)!}{N!A!B!C!D!} \tag{7}$$

A	B	A+B
C	D	C+D
A+C	B+D	N

where A: Between the same levels of certain assessment factor, there is X person recognition that is of importance; B: Between the same levels of certain assessment factor, there is Y person recognition that is of importance; C: Between the same levels of certain assessment factor, there is X person not recognition that is of importance; D: Between the same levels of certain assessment factor, there is Y person not recognition that is of importance; N is the cumulative of a total of persons of X and Y.

The test analysis results, through SPSS for windows statistical software, are as follows:

- The independence of each variable between the second levels, third levels and fourth levels did not reach a significant level ($P > 0.05$).
- This study must not only accept the null hypothesis but also establish independence and rationality for each variable of various levels (shown in Table 4).

6. Strategy proposals and discussion

6.1. Energy development of strategy proposals in the future

Through the process of research design, this study found twenty-seven items of key influencing factors with seven major objectives. Based on resistance and factors and according to the hierarchical framework design of the evaluation decision-making system a strategy was proposed for energy development proposals in the future. Descriptive details are as follows:

- *Economic development orientation*:
  The government should push technology R&D and cost reductions of RE equipment systems to increase people's willingness to use and install the technology. Using the characteristics and qualities of renewable energy through the government's policies support should be given to actively establish regulations mechanisms and application strategies. In addition, to formulate complete law supporting measures, the government should separately formulate preferential acquisition rates of economic incentives. The country should actively carry out the necessary technological research and development to reduce economic cost of facility settings and apply key technologies to carry out quantity designs of facilities and modules by strengthening the transfer of energy technology R&D. The country should input research and development and demonstration, along with suitable development of energy science and technology techniques, to improve competitiveness of energy technologies and to foster folk renewable energy industrial development and construct a quality developmental environment.
- *Energy exploiting orientation*:
  Renewable energy equipment system installation must ensure optimal effectiveness and system photoelectric conversion efficiency. In the stage of architectural design and planning considerations should be made for the possibility of using renewable energy and the combined suitability of building space and

Table 3
The statistical results of correlation test [65].

Level/Variables	Variables name		Spearman's rho(P-value)	Significance level	Research hypotheses results
Variables of first level and second level	ED	O1	0.576**	$P<0.01$	Accept H1
		O2	0.501*	$0.01<P<0.05$	Accept H1
		O3	0.504*	$0.01<P<0.05$	Accept H1
	EE	O4	0.456*	$0.01<P<0.05$	Accept H1
		O5	0.605**	$P<0.01$	Accept H1
	EP	O7	0.631**	$P<0.01$	Accept H1
		O9	0.588**	$P<0.01$	Accept H1
Variables of second level and third level	O1	C01	0.626**	$P<0.01$	Accept H1
		C02	0.523*	$0.01<P<0.05$	Accept H1
		C04	0.458*	$0.01<P<0.05$	Accept H1
		C05	0.480*	$0.01<P<0.05$	Accept H1
	O2	C06	0.558**	$P<0.01$	Accept H1
		C07	0.423*	$0.01<P<0.05$	Accept H1
		C08	0.577**	$P<0.01$	Accept H1
		C09	0.657**	$P<0.01$	Accept H1
		C10	0.439*	$0.01<P<0.05$	Accept H1
		C11	0.459*	$0.01<P<0.05$	Accept H1
	O3	C12	0.604**	$P<0.01$	Accept H1
		C13	0.473*	$0.01<P<0.05$	Accept H1
		C14	0.472*	$0.01<P<0.05$	Accept H1
		C16	0.434*	$0.01<P<0.05$	Accept H1
	O4	C17	0.757**	$P<0.01$	Accept H1
		C18	0.683**	$P<0.01$	Accept H1
		C19	0.469*	$0.01<P<0.05$	Accept H1
		C21	0.585*	$0.01<P<0.05$	Accept H1
	O5	C22	0.439*	$0.01<P<0.05$	Accept H1
		C23	0.502*	$0.01<P<0.05$	Accept H1
		C25	0.616**	$P<0.01$	Accept H1
	O6	C30	0.697**	$P<0.01$	Accept H1
		C33	0.707**	$P<0.01$	Accept H1
		C34	0.720**	$P<0.01$	Accept H1
	O7	C40	0.706**	$P<0.01$	Accept H1
		C41	0.472*	$0.01<P<0.05$	Accept H1
		C44	0.553**	$P<0.01$	Accept H1

* $0.01<P<0.05$.
** $P<0.01$.

equipment, self-sufficiency, and symbiotic potential of the main body with the natural environment. Renewable energy technology technique should continue strategic research and development and improvement, and further strengthen international technical cooperation and exchange, to create efficient, low-cost, quantity technological and the system stability of supply technology. In addition, efforts should be made to match up the "Renewable Energy Development Act" with the purchase of electricity subsidy measures to ensure domestically deployed solar PV systems and solar thermal systems power generation efficiency, and to enhance the technical ability of system vendors. These policy instruments also promote the all-regional deployment of solar communities and solar cities while establishing renewable energy for industry to complete the market supply chain.

- *Environmental protection orientation*:
Imports suitable renewable energy systems depend on the local environment characteristics. Through the subsidies for renewable energy demonstration systems and public building integration of RE equipment systems on buildings, people are provided with the opportunity to experience the educational opportunities of renewable energy and become aware of renewable energy exploitation and may offer their support and participation. The government should actively integrate the renewable energy investigative resources and optimum technical information, establish a complete database of renewable energy resources and technology, maintenance and management of mechanisms to promote the government formulation and review of policies. Moreover, government support and promotion strategies could successfully import and expand the market and according to the different industry characteristics implement horizontal and vertical integration, strategic alliances and different industry integration. This could expand the market size of the renewable energy industry, to promote a complete industrial supply chain and provide quality of the industrial development environment allowing industry to bring spillover effects to drive generating electric cost reductions, and further, to achieve a scale of quantity and an international competitive advantage.

6.2. Discussion

In recent years, green energy issues becoming a high priority, to some extent, have gone beyond the national levels to upgrade to the field of global issues. Faced with the depletion of global energy people must be fully aware of the trends of current global energy supply and demand, and develop alternate and renewable energy obtaining the successful development of renewable energy experience of advanced countries which is the primary task to enhance the competitiveness of national energy. Nevertheless, the current state of implementation and research indicates that to achieve high efficiency and popularity of renewable energy exploitation, it will be necessary for the government to support renewable energy by regulations and subsidies, to increase the degree of public

Table 4
The statistical results of independence test [67].

Level/Variables	Variables name		Fisher's exact probability(*P*-value)	Significance level	Research hypotheses results
First level variables	ED	EE	0.500	$P>0.05$	Accept H0
		EP	0.646	$P>0.05$	Accept H0
	EE	EP	0.344	$P>0.05$	Accept H0
Second level variables	O1	O2	0.500	$P>0.05$	Accept H0
		O3	0.129	$P>0.05$	Accept H0
	O2	O3	0.344	$P>0.05$	Accept H0
	O4	O5	0.279	$P>0.05$	Accept H0
	O7	O9	0.500	$P>0.05$	Accept H0
Third level of first group variables	C01	C02	0.640	$P>0.05$	Accept H0
		C04	0.366	$P>0.05$	Accept H0
		C05	0.658	$P>0.05$	Accept H0
	C02	C04	0.219	$P>0.05$	Accept H0
		C05	0.245	$P>0.05$	Accept H0
	C04	C05	0.672	$P>0.05$	Accept H0
Third level of second group variables	C06	C07	0.354	$P>0.05$	Accept H0
		C08	0.241	$P>0.05$	Accept H0
		C09	0.148	$P>0.05$	Accept H0
		C10	0.083	$P>0.05$	Accept H0
		C11	0.646	$P>0.05$	Accept H0
	C07	C08	0.364	$P>0.05$	Accept H0
		C09	0.085	$P>0.05$	Accept H0
		C10	0.151	$P>0.05$	Accept H0
		C11	0.500	$P>0.05$	Accept H0
	C08	C09	0.247	$P>0.05$	Accept H0
		C10	0.366	$P>0.05$	Accept H0
		C11	0.360	$P>0.05$	Accept H0
	C09	C10	0.636	$P>0.05$	Accept H0
		C11	0.083	$P>0.05$	Accept H0
	C10	C11	0.148	$P>0.05$	Accept H0
Third level of third group variables	C12	C13	0.636	$P>0.05$	Accept H0
		C14	0.500	$P>0.05$	Accept H0
		C16	0.364	$P>0.05$	Accept H0
	C13	C14	0.247	$P>0.05$	Accept H0
		C16	0.366	$P>0.05$	Accept H0
	C14	C16	0.245	$P>0.05$	Accept H0
Third level of fourth group variables	C17	C18	0.634	$P>0.05$	Accept H0
		C19	0.241	$P>0.05$	Accept H0
		C21	0.634	$P>0.05$	Accept H0
	C18	C19	0.141	$P>0.05$	Accept H0
		C21	0.634	$P>0.05$	Accept H0
	C19	C21	0.360	$P>0.05$	Accept H0
Third level of fifth group variables	C22	C23	0.646	$P>0.05$	Accept H0
		C25	0.344	$P>0.05$	Accept H0
	C23	C25	0.287	$P>0.05$	Accept H0
Third level of sixth group variables	C30	C33	0.364	$P>0.05$	Accept H0
		C34	0.640	$P>0.05$	Accept H0
	C33	C34	0.241	$P>0.05$	Accept H0
Third level of seventh group variables	C40	C41	0.634	$P>0.05$	Accept H0
		C44	0.366	$P>0.05$	Accept H0
	C41	C44	0.636	$P>0.05$	Accept H0

*$0.01<P<0.05$.

awareness, and to increase support and participation from the general population. Ultimately, this will lead to satisfactory results in terms of the application and installation of renewable energy.

Taiwan, in terms of environmental and geographic conditions and technological resources, exhibits great potential and competitive advantage for solar energy development. However, the actual progress is far less than expected, both in terms of policy formulation and promotion of positive response. Both of these are obviously difficult to implement. This study shows that the most important influence on renewable energy application on Taiwan buildings is government policy. The government should actively proceed to formulate applications and popularize solar energy technologies by instituting legislative incentives, supporting measures of incentive subsidies, setting economic incentives, and with access to support of government policy, fostering the renewable energy industry to seek international technical cooperation and exchange. The promotion of renewable energy policy will simultaneously drive the development of related industries and create employment opportunities and identity with the people. Therefore, relevant supporting measures for the implementation of key issues to amend or review relevant laws and regulations, and continuing promotion under the current system for implementation of more efficient processing procedures are necessary. Through the popularization of technology and implementation of solar energy to existing buildings and new buildings the government will break through the predicaments and challenges of existing resistance. It is only through the review of actual operations and positive strategic improvements that the country will obtain more environmental and energy benefits.

The study shows that in terms of different regions of the natural environment and geographical conditions, solar energy systems deployment must be in accordance with different geographical regions to plan and design optimal settings and improve the influence of the equipment system to achieve satisfaction with the economic benefits and system quality. In addition, government policies incentives should show appropriate innovative planning and review, in order to avoid inappropriate policies affecting the national financial and industrial markets [68]. Consequently, the history and experience of advanced countries in the successful development of renewable energy are important references and lessons (such as Germany, Japan and the United States).

The experts' decision-making consensus value for various objectives of unified average for "Geographic of environment" (O8, 6.3847) and "Management of maintenance"(O6, 6.5671) obtained a lower evaluation value and identification degree. However, the life cycle of solar energy systems, with regard to preliminary planning and design and subsequent systems management and maintenance, contains critical elements. This study showed that at the present stage these are not key resistances and challenges. The reasons can be divided into three parts for discussion:

- *Aspects of various countries*: Various countries in regard to the development and application of green energy are incorporating a lot of energy and resources, and using specific action programs to promote renewable energy application. In Taiwan this is also true. However, this study found that in recent years countries in active pursuit of breakthroughs and expanding installed capacity at the same time only focus on R&D and new systems development in the system life cycle. There is a lack of comprehensiveness and effectiveness of energy strategic planning. The role of evolution for countries in promotion strategy is to actively place R&D later in the period of system innovation and diversified technology, with innovative applications and consequently a lack of resources inputs the strategy of optimization planning.
- *Aspects of populace*: People in some countries focus their attention on the energy systems' conversion efficiency, system cost-effectiveness ratio, and the recovery of the investment period. People are only interested in the economic benefits and investment value of the systems equipment, with an indirect impact of the country on inputs of energy strategic planning of direction and imbalance phenomenon.
- *Aspects of RD&D*: The countries putting in funding for development and promotion of the renewable energy field found that the system RD&D, efficient performance improvement, technical R&D and innovation were the main advancements for renewable energy at present. However, there is a lack of effective feedback, review and improvement, resulting in the effectiveness of application and thus the promotion of renewable energy systems is limited.

In summary, the development and application of renewable energy should not only be limited to technologies of research and development, simulation and evaluation predictions of research. Countries should be involved in input and import of the applications of new energy technologies at the same time, according to the present state and resource conditions to conduct preliminary planning, assessment of application, forecasts of effects of imported technology and review and elimination of import difficulties and obstacles.

7. Conclusions

In recent years, the application and development of renewable energy has been flourishing because of shortages in fossil energy, impacts on the environment and sustainable energy usage. Nevertheless, the depletion of natural resources has forced planners and policy makers to look for alternate sources. Renewable energy is a sustainable and clean source of energy derived from nature. Thus, countries are actively seeking solar energy applications and improving industries' willingness to invest through subsidy policy instruments and application of quantity technology to guide cost reductions. Globally, countries are active in working on developing green energy industrially and renewable energy technologies R&D at the same time. Taiwan is also working on legislation incentives and renewable energy technology imports to integrate with the global trend. It is expected that green energy environment and renewable energy applications will bring new opportunities and prospects for the future.

Assessment of preliminary technical planning for energy system applications, and the forecast of effects of imported technology and review of work done are very important. Based on this, the study, through the history of promoted solar energy systems applications, formulated policy experiences in advanced countries further to reflection and exploration of the effectiveness of solar energy exploitation and promoted resistance and influencing factors in Taiwan. Through this study a stage process of research design was found in which the key factors which affect the application and promotion of solar energy systems are twenty-seven criteria in seven major objectives. In the evaluation decision making system, the assessment factor of expert decision-making consensus values was up to 7.1325, indicating expert decision-making groups have reached a consensus rating importance at a high degree. The assessment objectives which had the highest consensus degree of importance were "Government policy" with a score of 8.3647, followed by "Equipment system" with a score of 7.9223. FDM factor screening and decision-making results, through analysis of correlation tests and independence tests, obtained an overall evaluation decision-making system of rationality, correctness and operability after verification. Ultimately, this research proposes strategies for energy development in the future to provide to countries in view of their current energy policies, development strategies for energy technology and effective energy and resource management.

In summary, this research adopted Fuzzy Delphi Method to assess solar energy systems applications, based on the evaluation values of expert decision-making groups and FDM statistical analysis results to provide an operational evaluation decision making system model. Through the evaluation decision-making system model for the future of solar energy system application assessment, environment energy system deployment and technical R&D, it will be able to access assessment of preliminary technical planning and forecast the technology importing before and after implementation, especially for developing and under-developed countries.

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